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DISEASES AFFECTING MOOSE

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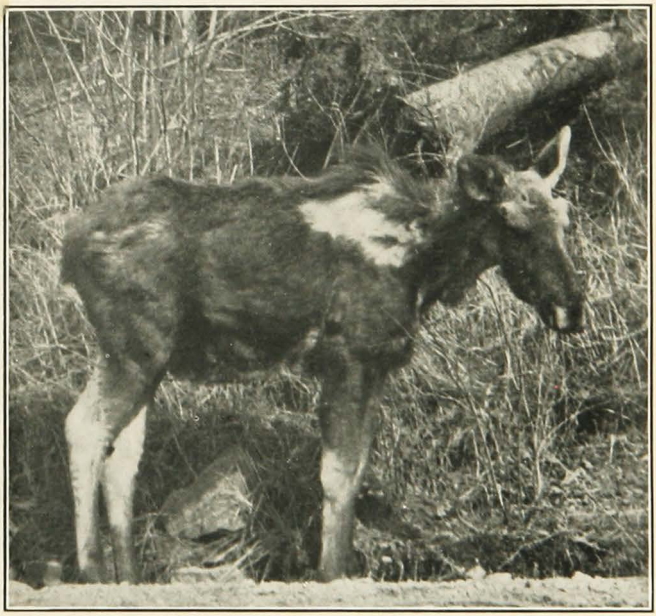

MOOSE NO. 3, PHOTOGRAPHED AT A DISTANCE OF 10 FEET. THIS ANIMAL HAD NO FEAR OF MAN AND WAS HEAVILY INFESTED BY *D. ALBIPICTUS*

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DISEASES AFFECTING MOOSE

R. FENSTERMACHER AND W. L. JELLISON[1]

A disease affecting moose in Minnesota has been studied, as opportunity afforded, for the last eight years. The disease was first brought to the attention of the Division of Veterinary Medicine in April, 1924, when the carcass of a moose that had been transported 40 miles by dog team and then by express was received at the laboratory.

This moose, in an emaciated and weakened condition, was found by a game warden in the northern part of Lake County. Decomposition made a careful bacteriological or pathological examination impossible. Large numbers of ticks were present on the skin and the hair was rubbed off in many places. No lesions of internal organs were noted.

The second moose, also from northern Lake County, was received November 30, 1926. This animal, according to the warden, showed depression, blindness, and marked weakness. It was thought that the animal might be affected with tularemia. Bacteriological examinations failed to show the presence of any specific disease-producing micro-organism. This was confirmed by the Division of Preventable Diseases of the State Board of Health. No definite pathology was found in the internal organs. Both moose showed an impacted rumen and it was thought possible that this condition might be the cause of the symptoms shown by the animals.

Reports were received from time to time during the next few years of sick and dead moose in northeastern Minnesota but none were examined. It became evident, however, that a more severe and serious condition prevailed among the moose than had been determined from the examinations. A detailed study was begun to determine, if possible, the cause and prevention of the sickness. It was possible that the sickness was infectious and transmissible to domestic animals. Therefore, not only from the standpoint of conservation of wild life was it desirable to have definite knowledge of the condition, but also for the preservation of the health of domestic animals. Material has been difficult to obtain. Progress has been slow. The country frequented by moose is often inaccessible.

The literature contains few references to disease among moose. Cameron and Fulton (1) report an outbreak of disease among moose

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in Saskatchewan. The animals were badly infested by the so-called "winter tick," known as *Dermacentor albipictus* Packard. They state there is no record of its causing serious injury to domestic animals until the winter of 1921-22. Game wardens of the province reported that early in the winter of 1921 moose were heavily parasitized by ticks and that several individuals had been found in a weakened condition. They found that *Dermacentor albipictus* may attack cattle and horses and cause serious losses. Domestic animals that are affected often graze in the haunts frequented by moose. Disease among domestic animals due to the tick was apparently brought about by peculiarly favorable circumstances in the outbreak studied by these authors. During preceding years, *Dermacentor albipictus* had increased in numbers. Moose also had increased, with the result that the ticks had become widely disseminated. The practice of pasturing cattle and horses in the woods made them liable to infestation by the larval ticks. These authors state that sporadic outbreaks of *Dermacentor albipictus* among cattle and horses are generally confined to those localities where settlers are "carving homesteads from the virgin forests." When the land is cultivated the native hosts of the tick gradually recede and reduce the liability of infestation among livestock.

A game warden (2) reported that in the spring of 1923 he found 11 dead moose in the vicinity of Moose Lake, Minnesota, near the Canadian border in Lake County. He observed an old cow moose that was so feeble she could hardly move and was heavily infested with ticks.

Zeller (3), forest supervisor in Superior National Forest, states that United States forest rangers in that district found, during the winter of 1931 and 1932, the carcasses of 12 dead moose.

Linklater (4) states that ticks were observed on moose in Minnesota since 1903. Ticks and blood are often seen along moose trails and in the beds of moose, in late winter.

Howard (5) reported the finding of *Dermacentor albipictus* Packard on elk imported from Montana and consigned to Itasca State Park, in 1915. They were heavily infested.

Riley (6) reports, "The presence of the so-called elk tick, *Dermacentor albipictus,* on moose in the northwestern part of the state . . ." (Minnesota). "This tick is believed to be the cause of the death of moose in that region. In some parts of northwestern United States and Canada, this species is a serious parasite of cattle and horses."

Bishopp and Wood (7) studied the biology of some of the North American ticks of the genus *Dermacentor.* They did most of their work in the southern states (Texas) but obtained considerable material from other parts of the country. They state that: "*Dermacentor albipictus*

has been considered of little or no economic importance until very recently. During these investigations we have found the tick to be an important pest of horses and cattle during the autumn, winter, and early spring. The tick is much more severe on horses than cattle, mainly owing to the preference shown for the former animal as the host. Reports have been received from California, Montana, and Oregon stating that horses and colts become very weak and colts not infrequently succumb if the ticks are not promptly killed. During the spring in territory infested by the Rocky Mountain spotted fever tick (*Dermacentor venustus*), the combined attack of these two species, together with a shortage of feed, often causes the death of numbers of horses when they are not promptly cared for." These authors list the states from which they had received specimens of this tick. Minnesota is not listed.

Thomas and Cahn (9) report that: "Guinea pigs and rabbits infested with the tick *Dermacentor albipictus* from diseased moose, have reproduced in detail the symptoms of weakness, anemia, paralysis, excessive blind activity and death as exhibited by infected moose, thus demonstrating the transmission of the moose disease through the tick." "The microscopic blood picture of diseased moose and that of infected guinea pigs and rabbits are similar. Tick paralysis is manifested in guinea pigs and rabbits as a result of the bite of *Dermacentor albipictus,* while animals which remove the ticks within 24 hours do not contract the disease."

Wallace, Thomas, and Cahn (10) report the finding of a bacterium-like organism in smears from the intestinal contents of ticks engorged with blood of diseased moose. "This intestinal content was cultured on dextrose agar and the organism isolated. A saline suspension of this pure culture was inoculated intravenously into guinea pigs and rabbits and all of the experimental animals died within 8 hours, exhibiting symptoms similar to those shown by guinea pigs and rabbits infected through the medium of the tick itself. The organism has been repeatedly recovered from the liver, spleen, lungs, heart, kidney, brain, bone marrow and urinary bladder of inoculated and infected animals." The authors state that indications are that the organisms isolated may be a member of the Klebsiella group.

Hadwen (8), reviewing an article by Jarvis on Exotic Lymphangitis, emphasizes the difficulties experienced among horses on the western slopes of the Rocky Mountains, in Canada. He states: "For a number of years past we have had outbreaks of fistulous withers and poll evil among unbroken range horses. These outbreaks frequently appeared early in the season and we have been at a loss hitherto to explain the predisposing causes: . . . Since I have read Captain Jarvis' article

I am convinced that ticks play an important rôle in producing fistulous withers. The following facts will bear out my contentions:

"*D. albipictus* would appear to be the worst offender and possibly also *D. venustus*. *D. albipictus* is commonly called the winter 'tick'; and in some regions of British Columbia, especially where poll evil and fistulous withers are common, horses are heavily infested with these tics . . . The necrosing action following the bite of *D. albipictus* on horses may be as great as the after effects of the bite of *D. venustus* which have been well studied in other animals. It is easy to see that these necrotic spots should be a favorable point of entrance for bacteria." . . . "In summing up, it would appear that owing to the habits the Dermacentors have of attaching in the region of the mane of horses it is probable that that may be the cause of producing more damage than we have hitherto suspected."

Cahn, Wallace, and Thomas (11) in a later article describe the organism above mentioned as a capsulated rod with a tendency to assume a coccoid shape. "It grows as an excessively mucoid colony on agar, and produces Beta hemolysis on blood agar. Its growth is extremely rapid, covering an agar slant in five hours, and it apparently produces an extra-cellular toxic substance." The authors believe that it is a new species and therefore designate it *Klebsiella paralytica*.

HISTORY

It is difficult to get authentic reports in regard to disease among moose. Nothing in the literature indicates when disease among moose was first definitely recognized. Sick and dead moose have been observed in northern Minnesota at least since 1912. Definite information as to numbers and symptoms is not available. Moose abhor civilization. Northeastern Minnesota is becoming more and more civilized and moose are gradually moving out. Modern transportation and better game conservation have furnished means of learning more of the habits of moose and conditions surrounding them. For these and other reasons sick and dead moose are given more attention than they were 25 or 30 years ago. All the records, however, indicate that sick moose were observed at least 20 years ago, and that moose then were infested with ticks; that the moose is a preferred host of *Dermacentor albipictus* and that infestation is common.

The finding of dead and diseased moose does not seem to be confined to any particular section of northern Minnesota. It is true that more sick moose are found in St. Louis and Lake Counties than in any other part of the state. It is impossible to estimate the extent of mortality among moose in this state. In the first place, there is no accurate census of the moose, and in the second place, no doubt many

dead moose never come to the attention of wardens and are consumed by predatory animals. Whether the mortality is increasing or decreasing is not known. We are inclined to believe that the condition is on the increase.

SYMPTOMATOLOGY

Affected moose show rather definite symptoms. Ordinarily a moose is very timid and has great fear of man. It is difficult to approach a healthy one except during the time of the year when flies and other insects are numerous. Then moose will go to streams and lakes, and if one travels by canoe it is possible, by using care, to approach relatively near one or a group. Even then, when they discover the presence of man, they immediately rush into the wilderness. The most distinctive feature noticed as common to all sick moose is that they do not show the usual fear of man. Several sick moose observed in these studies have been found near homes or on the main travelled highways. Wherever they are they show a marked tendency to remain near the place. They may be driven away but they soon return. One yearling moose observed could be led by placing one hand on its nose and with the other hand grasping one ear. Another was led two miles by a rope around its neck. The others were not so docile. Some moose lingered for several weeks in one locality. One yearling bull moose appeared near a settler's home on the North Shore Road of Lake Superior near the Cascade River. It lay down in the farmyard and during the afternoon a flock of chickens picked the ticks from it. All moose studied have been weak, manifested by an unsteady or staggering gait. Paralysis has never been noted as a symptom of disease in moose. Some of the animals act as if they were partially blind. They run into small trees or other objects. The same animals, however, a little later may appear to have perfect eyesight, avoiding all objects in their way. The apparent blindness may not be similar or the same as that exhibited by normal, frightened moose that will rush through the woods and make no effort to avoid obstructions.

All sick moose observed that have been driven from one place have a tendency to travel in a circle and make an attempt to return. One of the moose studied was on a small island. One could get within 25 to 30 feet of this animal without difficulty. The lake was frozen. Seven men were able to drive it approximately 100 feet off the island but they were unable to prevent its return.

Emaciation has been common to all specimens studied. The emaciated condition may be extreme or partial. Normal moose carry less flesh in the spring than in the fall. Food is not abundant in winter so in spring an animal would be more or less emaciated. In the fall, however, a normal moose is usually sleek and fat. A sick moose studied in the fall showed marked emaciation.

All the moose except one that were examined after death had been infested more or less by the winter tick, *Dermacentor albipictus* Packard. Some had been so badly infested that not a single place was found in the areas frequented by ticks that were not covered with them.

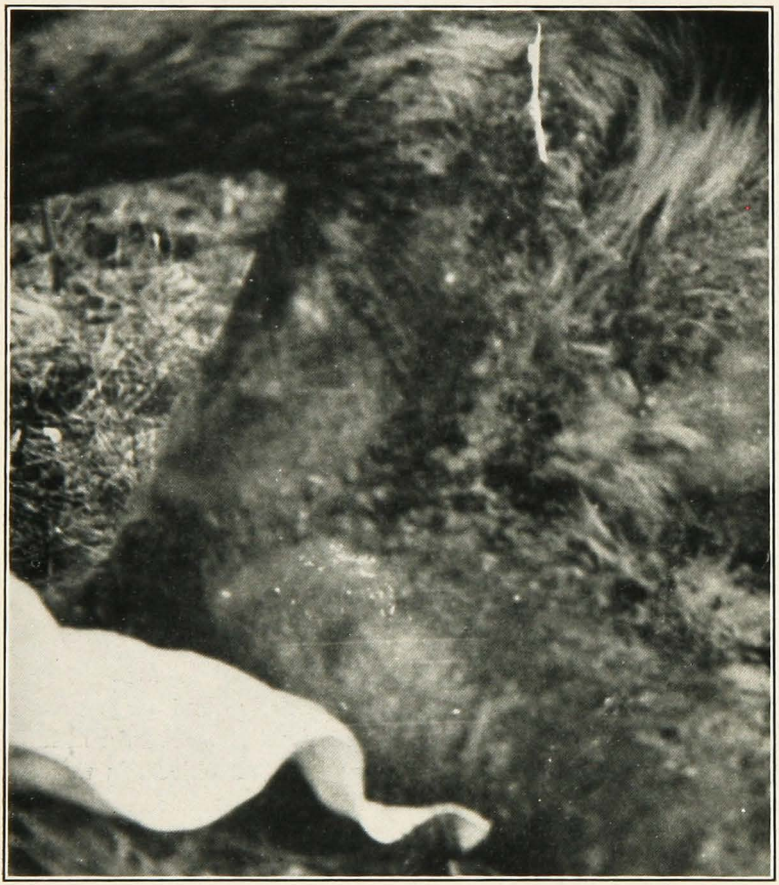

Fig 1. Ventral Portion of Moose No. 1.

The skin is without hair in many places, particularly on the shoulders, ventral and lateral sides of the abdomen, the pectoral and inguinal regions, the medial surface of the femoral region and the posterior surface of the hind limbs and the anus. Wherever it is possible for the moose to rub against objects, the hair had usually been worn off. The skin in these areas has a thick, leathery appearance similar in some respects to that of cattle affected with mange. Dried blood was found adhering to the skin. Blood may sometimes be seen along the trails and on windfalls frequented by tick-infested moose. Blood is occasionally found in their beds.

NECROPSY FINDINGS

We have examined, on necropsy, 13 moose. Some of these examinations have been very incomplete.

The hair, as has been noted above, is worn off in many places. On some moose large numbers of ticks were found; on others there were fewer but evidence of previous heavy infestation. The favorite locations of the ticks are around the anus, the inguinal region, sternum, inner parts of the conchal cartilage, over the withers and down further on the shoulders. The degree of infestation of moose is exceedingly variable. The largest number of ticks is found on the animal during February and March. More may be noted then because in these months the ticks are largest. It was necessary to use a clipper on the hair of one animal examined on October 30, in order to find the small larval and nymphal ticks, of which there were large numbers on the animal. Scabs and scars are found largely on the ventral portions of the abdomen, the sternum, and the neck. Yearling moose examined showed protruding ani, owing to the heavy infestation. The anal region apparently is a favorite location.

Fig. 2. Moose No. 2. Note loss of hair on back.

On opening a carcass one is immediately impressed with the absence of fat. The emaciation in some cases has been extreme; in others, small amounts of fat were noted, especially in the lumbar region and in the mesentery and omentum. In some cases where tick infestation had been severe, the blood appeared very light in color, indicative of anemia.

The lungs in six animals examined showed infestation with worms, identified as *Dictyocaulus hadweni* Chapin, 1925. In some cases the infestation was severe; in others, only a few worms (one or two) were found. Both principle lobes of the lungs were involved. Congestion of the lungs was noted in the areas infested with the parasites. Nodules in the lungs of five cases were recognized. They varied in size from ½ to 15 centimeters long. They are usually cylindrical. They always contain fluid and are the cystic stage of an Echinococcus. These cysts may be recognized by the discoloration of the lungs on the superficial surface or they may be found by running the hand over the surface of the lungs, or by palpation. The lungs contained from one to six cysts. F. G. Wallace demonstrated by experimental feeding to a dog that these are cysts of *E. granulosus*.

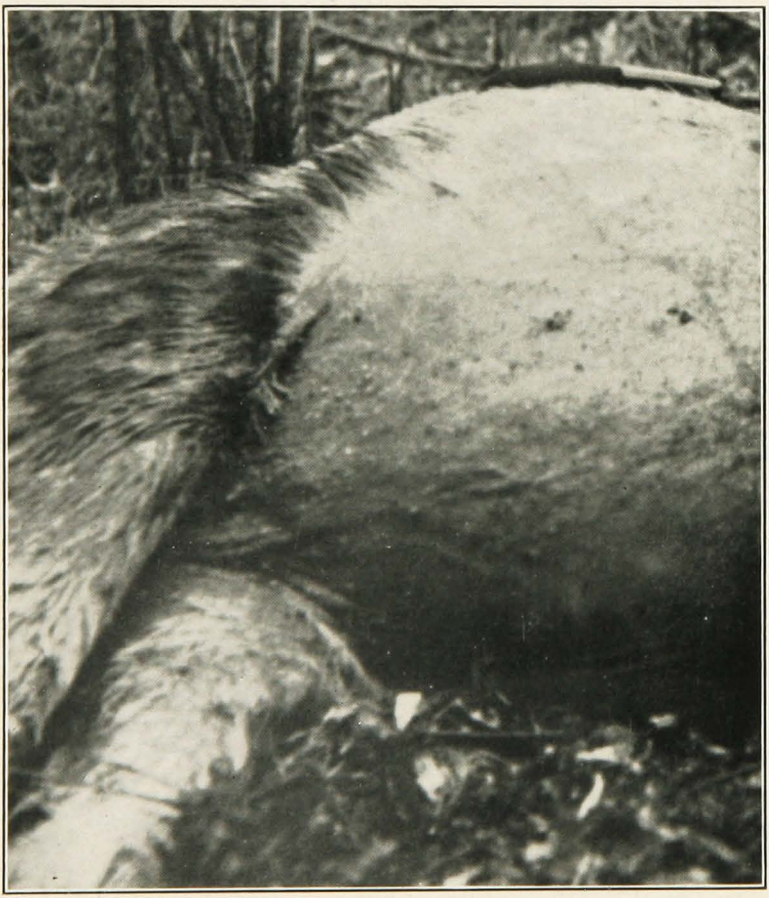

Fig. 3. Moose No. 5. This shows loss of hair. This was not a sick moose.

Few pathological changes are found in the heart. On the myocardium of one moose, however, several parasitic cysts were found. These were not definitely identified.

Parasitic cysts on the surface of the liver were found in eight cases. They were identified in one case as *Cysticercus tenuicollis,* the mature form of which, *Taenia hydatigena,* parasitizes the dog, the wolf, and related carnivores. No other pathological changes of the liver have been noted.

No visible changes were shown on the spleen, the kidneys, or the bladder.

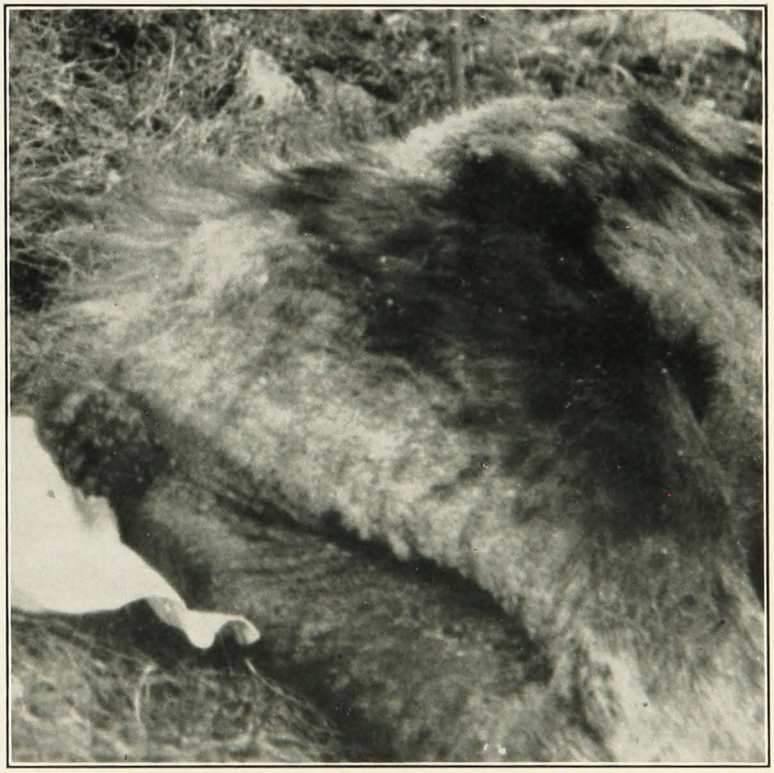

Fig. 4. Moose No. 1. Note mass of ticks attached to anus.

The rumen is usually well filled with food. The contents vary markedly with the time of year and the locality. In the fall and especially near lumber camps, considerable clover and timothy are found in the rumen. In the spring the contents consist largely of balsam, birch, and popple twigs. Sometimes, even then, clover has been noted in the rumen contents. Moose apparently will dig through the snow in sparsely covered areas to obtain the frozen plants. Moss is frequently

found. The contents of the rumen may be hard and dry or in some cases contain considerable moisture. In the earlier cases examined evidence of impaction was found. Other cases showed no evidence of this disturbance. *Paramphistomum cervi* has been noted in two cases. They were attached to the mucous membrane of the rumen in considerable numbers. The greater number of parasites was found on the mucous membrane of the passage between the rumen and the reticulum. Ingesta in this area contained enormous numbers of the flukes. A single parasitic cyst was found on the surface of the rumen in two cases. They were not identified.

No changes were found in the reticulum, the omasum, or the abomasum.

Congestion of the mucous membrane of the small intestine seems to be a constant and possibly a normal finding. This congestion increases toward the posterior gut. Mucous coating of the fecal pellets in the colon was constantly noted and is apparently a normal finding. Nematodes have been found in the small intestine of three cases. In one case, the infestation was heavy; in the other two, mild. The nematodes have been identified as *Nematodirella longispiculata* (12). Six cestodes identified as belonging to the genus Moniezia were found in the intestine of one moose. A parasitic cyst similar to that found on the rumen and liver was noted on the mesentery of two cases.

The brain showed congestion in three cases. This congestion was particularly noticeable in the meninges covering the cerebrum. No gross changes were found in the spinal cord.

The nares, posterior nares, larynx, pharynx, and esophagus have shown no visible lesions.

Changes were noted in the bone marrow of the femur. These changes were found to correlate with the condition present in the blood. Hyperplastic bone marrow was noted with a high erythrocyte count; hypoplastic bone marrow with a low erythrocyte count.

BLOOD STUDIES

Blood specimens were collected from all moose destroyed for necropsy. The jugular vein was punctured as soon as possible after shooting and blood smears on glass slides were immediately prepared. A quantity of blood was drawn into a flask containing 20 per cent potassium oxalate. Twelve ounces of blood was added to one ounce of the oxalate solution, and was used for inoculations. Blood was obtained for making counts and hemoglobin determinations in the following way: 0.5 cc. of a 20 per cent solution of potassium oxalate was evaporated to dryness in a test tube. To this was added 3 cc. of uncoagulated blood and the two were thoroly mixed. Diluting pipettes for making blood counts could not be filled satisfactorily at the place of necropsy.

They were filled later with the oxalated blood and fairly satisfactory counts were obtained. Whole blood was collected in sterile test tubes for serological examinations. Blood counts have been made on seven moose. The numbers of erythrocytes have varied from 1,020,000 to 5,250,000; leucocytes, from 1,770 to 12,220; hemoglobin, from 30% to 95%. Hemoglobin determinations have been made by Tallquist's or Dare's hemoglobinometer. The differential leucocyte counts show wide variation. The lymphocytes vary from 20 to 42%; polymorphonuclears, from 56 to 80%; eosinophils from 0 to 6%, and basophils from 0 to 3%. The last moose was examined on October 30, 1932.

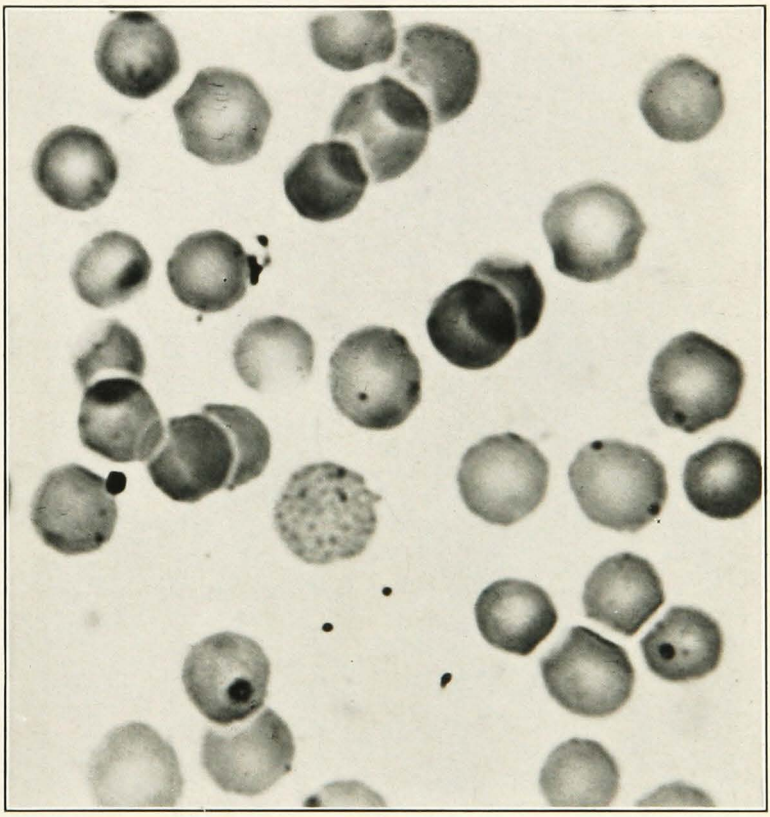

Fig. 5. Photomicrograph (2500x) of Blood Smear of Moose No. 3.
The erythrocyte in the center shows the granular inclusion bodies (basophilic stippling). The black dots are artifacts.

It showed no evidence of anemia on the basis of the blood count. (Erythrocytes 5,250,000, hemoglobin 95% by Tallquist.) It did, however, show typical symptoms of disease. Basophilic stippling of erythrocytes in cases that show anemia seems to be the most striking patho-

logical feature. The proportion of the cells showing inclusion bodies is about 1 to 250. Some of the erythrocytes contained as high as 45 to 50 bodies. They were not confined to a marginal location. The large majority of erythrocytes containing these bodies had 25 to 30 and were rather evenly distributed throughout the cytoplasm of the cell. Smears made from the bone marrow of these cases also showed on examination erythrocytes with similar inclusion bodies. Properly stained blood smears failed to show evidence of spirochetes, anaplasma, piroplasma, or other blood parasites. In moose No. 6 we were not able to obtain satisfactory blood for making leucocyte and erythrocyte counts. This animal, unfortunately, was shot through the stomach and a great deal of the blood escaped into the abdominal cavity. The blood collected was obtained directly from the heart and undoubtedly the cellular elements had settled out to some extent. The counts obtained from the specimen in this way were 1,020,000 erythrocytes and 12,220 leucocytes with a 30% hemoglobin by Tallquist. Anisocytosis and poikilocytosis were constant findings. These changes were more marked in the blood with the lower hemoglobin. Jolly bodies were found in the blood of moose Nos. 4, 5, and 7. Band formed neutrophils were present among the leucocytes of moose No. 1. They amounted to 5% of the total number of leucocytes.

BACTERIOLOGICAL AND SEROLOGICAL FINDINGS

It has been difficult to make bacteriological cultures under conditions in the field where moose are found. Often it is either raining or snowing or there is a high wind. Cultures were made in the field from the organs of eight moose on 10% horse serum agar. Specimens were brought to the laboratory and anaerobic cultures prepared from the lungs, liver, kidney, spleen, brain, and heart's blood. The cultures were incubated for at least 10 days. Duplicate cultures in some cases were prepared in the field and in the laboratory. Cystine agar and solidified blood serum have been used in the laboratory in all cases. Infusion bouillon has also been used. Some colonies thought to be contaminants were observed. In general, however, the cultures remained free of growth. No definite pathogenic organism was isolated from the cases studied except, possibly, an organism isolated from a mixed culture prepared from a blood smear from a moose submitted by Dr. J. E. Thompson, of Ely, Minnesota, on March 16, 1932. This organism was in the blood smears and it was isolated. The following is a description:

A gram-negative rod that becomes filamentous as cultures age and that may have club-shaped ends on the filaments. The filaments are sometimes swollen, showing gram-positive areas. The or-

Table 1

Results of Blood Examinations

Moose No.	Date	Hemoglobin	Erythrocytes	Leucocytes	Lymphocytes %	Polymorphonuclears %	Eosinophils %	Basophils %	
1	April 23, 1931	60 T	2,536,000	7,110	25	75	..	..	Basophilic stippling
2	April 25, 1931	80 T	3,360,000	3,770	42	58	..	..	Basophilic stippling
3	April 18, 1932	60 D	3,010,000	6,000	20	80	..	..	Basophilic stippling
4	April 30, 1932	70 T	4,090,000	1,770	44	54	1	1	Basophilic stippling
5	May 1, 1932	80 T	4,490,000	1,770	38	56	6	..	Basophilic stippling
6	June 2, 1932	30 T	1,020,000	12,220	30	68	2	..	No. stippling
7	Oct. 30, 1932	95 T	5,250,000	4,440	34	62	1	3	No. stippling

Table 2

Summary of Other Material Secured

Moose No.	Date	Material secured for examination	Condition at time of necropsy	Examination conducted
8	Feb. 26, 1931	All organs and tissues	Sick. Killed	Parasitological, Bacteriological, Pathological
9	April 6, 1931	Entire carcass Blood smears	Found dead	Parasitological, Partial hematological
10	May 9, 1931	Blood smears	Sick. Killed	Parasitological, Partial hematological
11	Mar. 16, 1931	Blood smears Portion of skin containing ticks	Found dead	Parasitological, Bacteriological, Partial hematological

ganism grows luxuriantly without formation of acid or gas in infusion bouillon containing dextrose, lactose, saccharose, mannite, and maltose. Litmus milk remains unchanged. It produces a heavy, yellowish-white growth on potato. At 3:00 p.m., June 7, 1932, two guinea pigs were inoculated intraperitoneally with one cc. of a saline suspension prepared from a serum agar culture of this organism. Both were dead at 11:00 a.m. the following day. The same gram-negative organism was isolated from the peritoneal fluid, liver, and heart of these pigs. The abdomen was much distended with a yellowish fluid. Two more guinea pigs were then inoculated with a similar suspension. One died and one showed no ill effects of the inoculation. The organism was isolated from the dead pig. Later, two more guinea pigs were inoculated intraperitoneally with one cc. saline suspension, with negative results. Three rabbits were inoculated intraperitoneally with one cc. saline suspension on June 10, 1932. One died several weeks later and

the cause of death was not determined. Cultures from the internal organs remained sterile. Negative results were obtained with the other two rabbits. Two chickens were inoculated intraperitoneally with one cc. saline suspension on June 10, 1932. The results were negative. The organism has not been classified. It is believed to have nothing to do with the disease among moose and was probably a contaminating saprophyte, as the moose from which the blood smears were obtained had been dead approximately two days before necropsy.

Fig. 6. Skin from Anterior, Ventral Portion of Moose No. 9.
A small number only of the ticks, *D. albipictus*, remained attached at the time the photograph was taken.

Guinea pigs and rabbits have been inoculated intraperitoneally and subcutaneously with organ and tissue suspensions of the moose. No evidence of disease was detected in any of the inoculated animals. The oxalated blood has been injected in doses up to 5 cc. intraperitoneally into both guinea pigs and rabbits. Negative results were obtained. One Holstein heifer, weighing 405 pounds, was injected intravenously with 60 cc. of the oxalated blood from moose No. 6. This animal

was held under observation for three months and no evidence of disease was detected. During this time she gained 105 pounds in weight.

Dr. R. G. Green, of the Department of Bacteriology of the Medical College, was furnished with more than 2,000 ticks from three moose. He made inoculations of suspensions, made by macerating these ticks, into a large number of guinea pigs. The spleen of all pigs dying from the first inoculation was reinoculated. Guinea pigs of the second series remained well. Dr. Green reports that he has been unable to find any evidence of tularemia in the ticks.

The blood drawn directly from the moose has been examined serologically with antigens prepared from *Bacterium tularense* and *Bacterium abortus*. In no case has evidence of these diseases been found.

Attempts were made to have the ticks from four moose attach to guinea pigs and rabbits. The ticks from two moose that did attach, however, did not become engorged. They remained attached for about 10 days. Transparent vaccination shields have been used to hold ticks in place on the animal. No evidence of disease has been observed in the animals to which the ticks have attached. Fifty larval ticks obtained from moose No. 7 were macerated in saline solution and the suspension was filtered through filter paper. One cc. of this filtered suspension was injected subcutaneously into a guinea pig at the junction of the thoracic and lumbar vertebrae. This was repeated with five lots of 50 ticks each. No evidence of disease was detected after two months in the inoculated pigs.

MICROSCOPIC ANATOMY

Portions of various organs and tissues were fixed in Zenker's solution and 10 per cent formaldehyde. Slides for microscopic examinations were prepared and stained in several ways. The stains used include hematoxylin and eosin, hematoxylin and methylene blue, basic fuchsin, Gram-Weigart, and a special stain for the demonstration of Negri bodies. No significant pathological changes have been observed in any of the sections.

DISCUSSION

This study has been carried on for eight years but most actively during the last two years. The difficulties that occur in obtaining proper material for study are pointed out. Moose Nos. 1, 2, 4, and 5 showed no symptoms of disease. They were thin, tick-infested animals from the wilderness. Moose Nos. 3, 6, and 7 showed definite evidence of disease and probably would have died within a short time had they not been destroyed. Moose Nos. 8 and 10 showed symptoms of disease and were destroyed. Moose Nos. 9 and 11 were found dead.

The findings to date have been almost entirely negative so far as determining the cause of sickness and death among moose. Necropsy findings give no suggestions as to the cause of the sickness. Bacteriological findings are also negative as are the results of animal inoculations. The organism isolated from the blood smears of Moose No. 11 we do not believe is significant altho on first inoculation apparently pathogenic for guinea pigs. Parasitological findings have been varied. The only constant parasite apparently is the so-called winter or moose tick, *Dermacentor albipictus* Packard. With the exception of Moose No. 7, specimens were secured largely in the spring, when moose are generally in the poorest physical condition. The last few winters in Minnesota have not, however, been especially severe. Conditions surrounding the moose in the northern part of the state have not been unusual from the standpoint of weather. It is not surprising that moose are found thin and emaciated in the spring.

It does not seem possible to evaluate in definite terms the significance of the infestation of these animals with *Dermacentor albipictus* Packard. This has been the only reasonably constant finding. The results of the investigation do not indicate the significance of this parasite for domestic animals. A careful study was made of the regions where the moose live and no ticks were found on cattle or horses. In one instance a horse was roaming the woods in the vicinity of a sick moose but no ticks were found on the horse. Deer (*Odocoileus virginianus*), which were plentiful in this region, were tick-infested.

Cameron and Fulton (1) as well as Bishopp and Wood (7) have data to indicate that this tick may be an important disease-producing parasite of our domestic animals, especially to the horse. The parasitism of domestic animals by *Dermacentor albipictus* has not been observed in these studies.

The possibility that the ticks may be a vector of some bacterial or protozoan disease is fully recognized. The transmission of the infection to guinea pigs and rabbits has failed.

Moose No. 7, obtained in October, 1932, showed definite evidence of disease so far as symptoms were concerned. Autopsy findings, bacteriological and serological findings were negative. At one time it was thought that the trouble was a digestive disturbance due largely to the restricted diet and severe living conditions of winter. This animal, found in the fall, confirms the further observation that the condition is not one primarily due to lack of food. These two factors (ticks and food) no doubt play at least a part in the production of the symptoms noted. We believe that some undiscovered, underlying factor or factors are responsible for the symptoms.

The moose examined that show the symptoms of disease have largely been yearlings. The condition may not be more common in

this group than in older animals, as no opportunity has been offered to examine a sufficient number of sick animals.

The presence of internal parasites, with special reference to Echinococci and lung worms certainly would not account for the symptoms. Nematodirella and Moniezia, too, have been found. These undoubtedly play some part in emaciation and the lack of thrift. The basophilic stippling of erythrocytes, which has been the most outstanding pathological feature recognized, is indicative of severe anemia. This is shown further in the small erythrocyte count and hemoglobin content. The parasitism may not be the chief cause of this condition. It must, however, be a factor in its production. It is interesting to note that basophilic stippling has been found in all cases examined except moose Nos. 6 and 7.

No ticks were found on moose No. 6 but the condition of the skin indicated that it had been tick-infested at some prior time. Moose No. 7 was infested only with larval and a few nymphal ticks.

Bishopp and Wood state that their records indicate *Dermacentor albipictus* is found on hosts only during the late fall, winter, and early spring. The tick remains on the host for both moults. The engorged female drops off the host and oviposits on the ground in the most protected place available. The incubation period at Dallas, Texas, was found to vary from 33 to 71 days. These authors further state that after hatching the larvae remain on or near the egg mass from which they emerge. As cooler weather approaches the larvae crawl about and become attached to their host.

The knowledge of diseases of wild animals as they occur under natural conditions is very meager. It is possible that an entirely new and hitherto undescribed pathogen is the cause of disease among moose; also that the conditions studied are brought about through several forces co-operating to reduce the vitality of moose and produce the symptoms observed.

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